NACA

RESEARCH MEMORANDUM

COMPRESSIVE BUCKLING OF FLAT RECTANGULAR PLATES SUPPORTED BY RIGID POSTS

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

WASHINGTON

November 9, 1948

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SUMMARY

Results of a theoretical investigation of the compressive buckling of flat, rectangular, simply supported plates supported in the interior by equally spaced rows of rigid posts are presented. It is found that the plates buckle as if simply supported along all of the transverse lines or else all of the longitudinal lines passing through the rigid posts, the occurrence of the one buckling mode or the other depending on the number and spacing of the posts.

INTRODUCTION

Aerodynamic requirements for high-speed flight have led to the use of thin wings on modern aircraft. As a result the space allotted for structural parts is inadequate for the conventional skin-stringer construction used in aircraft design. This inadequacy has necessitated the development of new constructions. One type that has been used is multicell construction in which thick skins are stabilized by longitudinal webs (references 1 and 2). As an alternative to multicell construction, the use of thick skins stabilized at discrete points by posts has been suggested.

Preliminary to a more complete study of post construction, the compressive buckling of flat, rectangular, simply supported plates supported in the interior by equally spaced rows of rigid posts (fig. 1) has been investigated. The results of this investigation are presented herein.

SYMBOLS

E Young's modulus for plate material

μ Poisson's ratio for plate material

t plate thickness

D plate flexural stiffness per unit width $\left(\frac{Et^3}{12(1 - \mu^2)}\right)$

b plate width

L post spacing in longitudinal direction

N number of bays in transverse direction

σ critical stress

k buckling stress coefficient $\left(\frac{b^2\sigma t}{\pi^2 D}\right)$

RESULTS AND DISCUSSION

The problem investigated is the compressive buckling of flat, rectangular, simply supported plates supported in the interior by equally spaced rows of rigid posts (fig. 1). The longitudinal spacing of the posts is equal but different from the transverse spacing. The solution of this problem yields an upper limit to the buckling load capable of being carried by a plate supported by very stiff posts. A theoretical investigation of possible buckling modes has revealed that the plates buckle as if simply supported along all of the transverse lines or else all of the longitudinal lines passing through the rigid-post supports.

It may generally be assumed that there are an infinite number of posts in the longitudinal direction and that the longitudinal spacing of the posts is not greater than the plate width. The plate then buckles with transverse nodes passing through the posts and with the buckling stress coefficient given by

$$k = \left(\frac{L}{b} + \frac{1}{L/b}\right)^2 \tag{1}$$

except when

$$\frac{L}{b} \leqq \left(N - \sqrt{N^2 - 1}\right) \tag{2}$$

in which case buckling with longitudinal nodes passing through the rigid posts prevails and the buckling stress coefficient is given by

$$k = 4N^2 \tag{3}$$

Equations (1) and (3) are rearrangements of well-known stability criterions for flat, rectangular, simply supported plates. (See, for example, reference 3.) Equation (1) expresses the stress required to buckle simply supported plates of length L and of width b (where $b > L$), whereas equation (3) expresses the stress required to buckle infinitely long plates of width b/N.

A chart for the buckling stress coefficients of infinitely long plates is given in figure 2.

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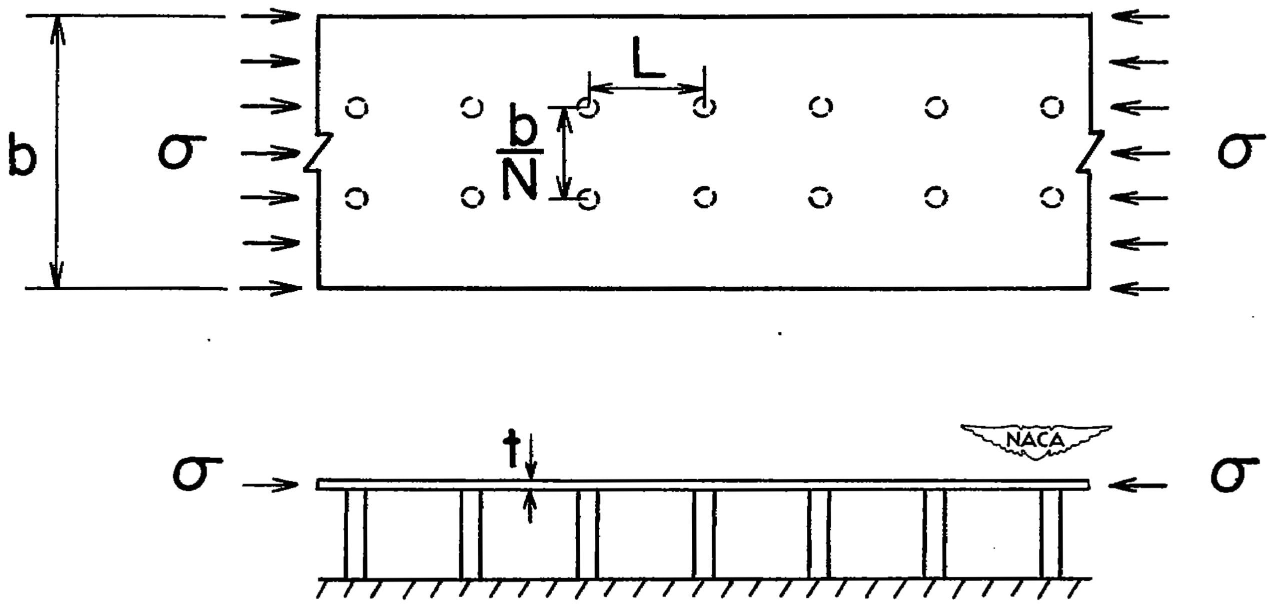

Figure 1.– Typical example of an infinitely long, flat, rectangular plate simply supported along the edges and supported in the interior by any number of equally spaced rows of rigid posts.

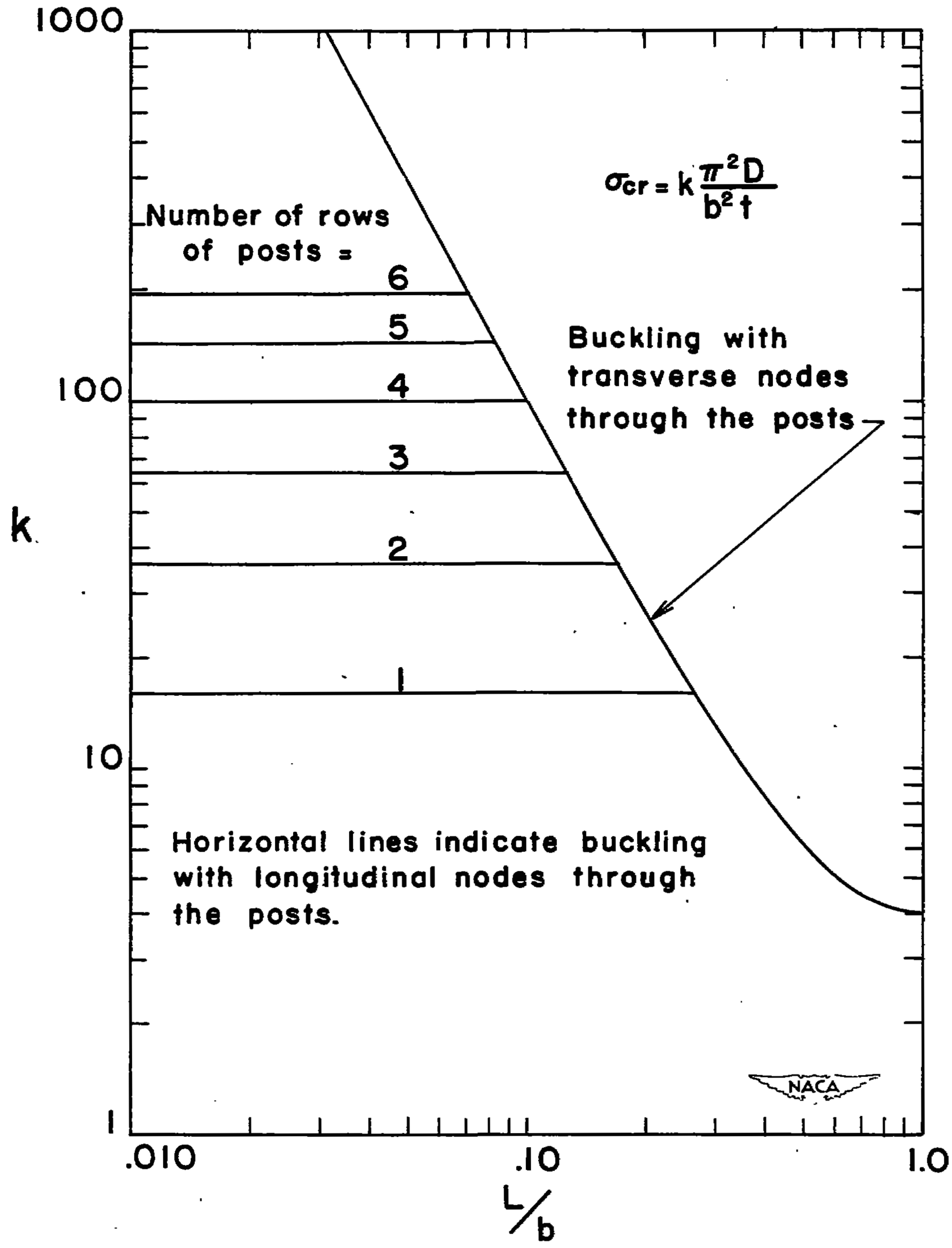

Figure 2.– Buckling coefficients for infinitely long, flat, rectangular plates simply supported along the edges and supported in the interior by rigid posts.